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**GB 818292**  
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**(54) Brushgear in a compact electric motor**

(57) A holder for a brush 25 in an electric motor comprises a piston 23 which is free to slide within a cylinder 21; the piston moves in the same direction as that in which the brush moves e.g. in response to vibration or shock generated in the motor, or in following an unevenly worn commutator surface; and the piston 23 acts on a fluid 26 to apply a force to a further piston 24 which is attached to the brush 25, the force opposing the movement of the brush. In other arrangements (not shown), a piston (511 Fig. 5 or 613 Fig. 6) and a fluid provide a coupling between the brush holder and the motor frame; a piston (714, Fig. 7) attached to a brush (75) reacts with fluid in a small gap (715); a large diameter pressure spring (83) is used; a spring (91, Fig. 9) surrounds a brush (92); co-axial pistons, one (107 Fig. 10) within the other (105), are used.

### Two important problems for

electric traction motors are limited space for sufficient power, and uneven wear of the commutator.

Accordingly It is described how a re-arrangement of the commutator can facilitate more compact brush holder design to give greater length of armature on the same length of rotor shaft. It is then shown how the brushes can be balanced to negate the effect of their own inertial responses to vibration and shock, and reduce the largest factor of uneven commutator wear.

Various designs are suggested, to cover a range of installation limitations and various service advantages.

Figure 1 in the specification shows how, with the methods described, motor winding space can be increased within the same size motor frame. Figure 3 then describes by means of 'electrical analogue', the dynamic function of the inertial balancing mechanism, and Figure 10 shows a 'fail-safe' embodiment of such mechanism.

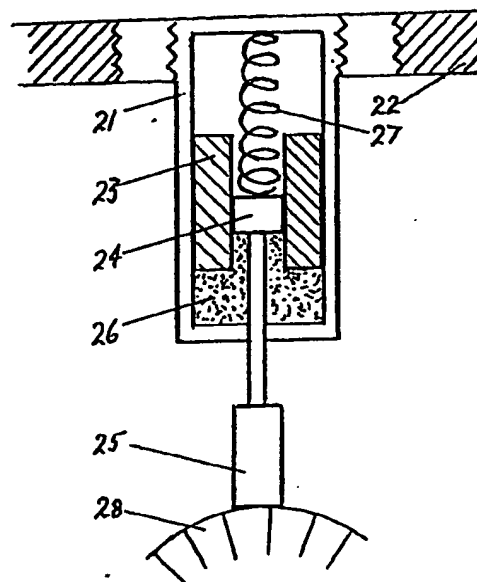
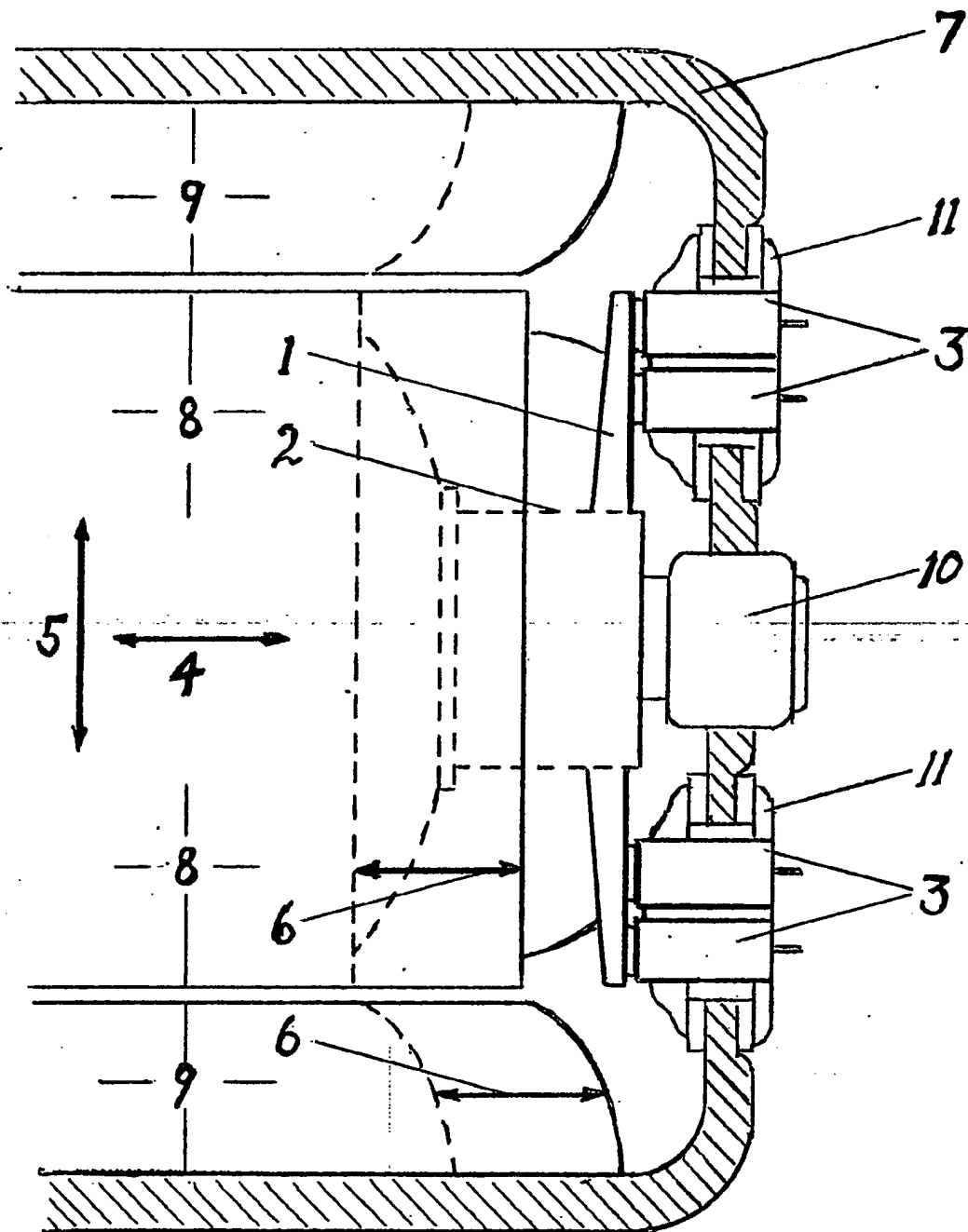


FIG. 2

1/5.

FIG. 1

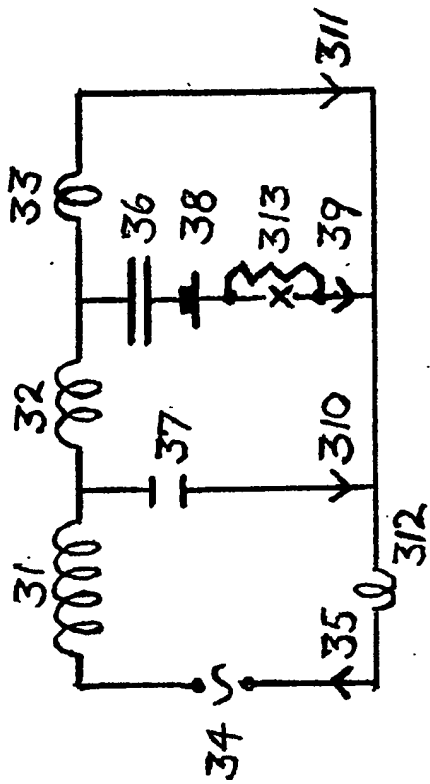


Fig. 3

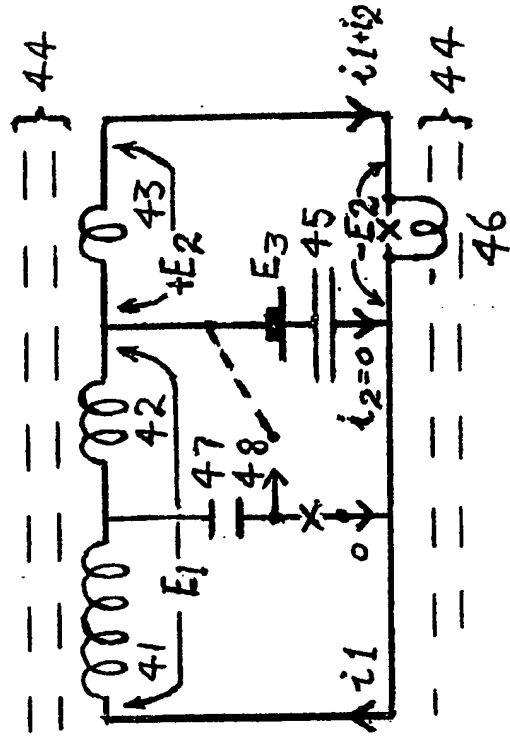


Fig. 4

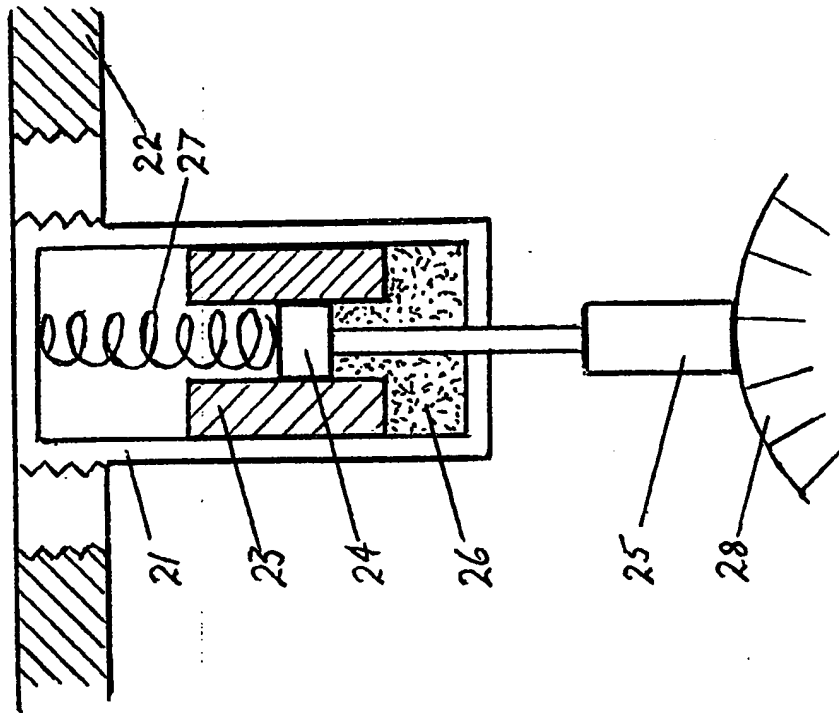


FIG. 2

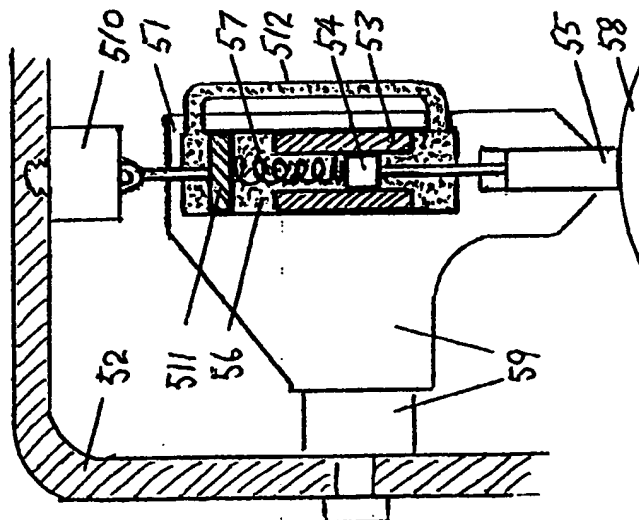


FIG. 5

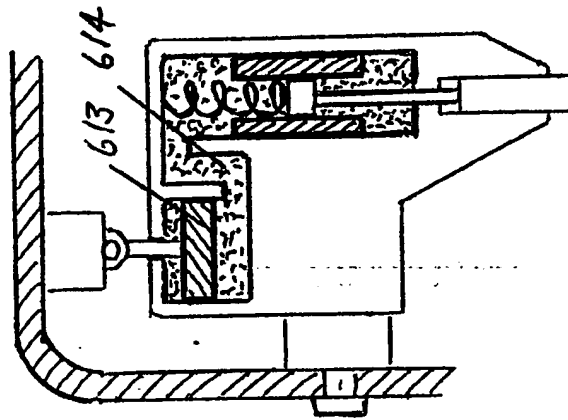


FIG. 6

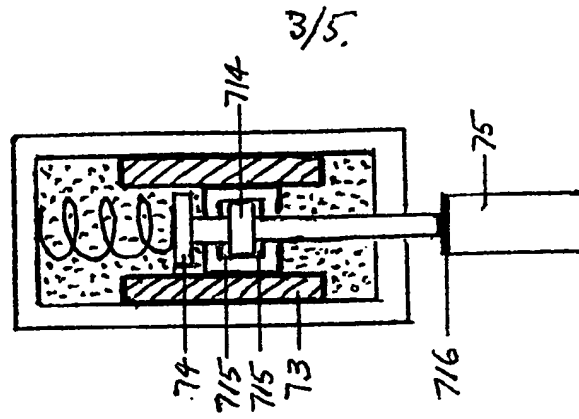
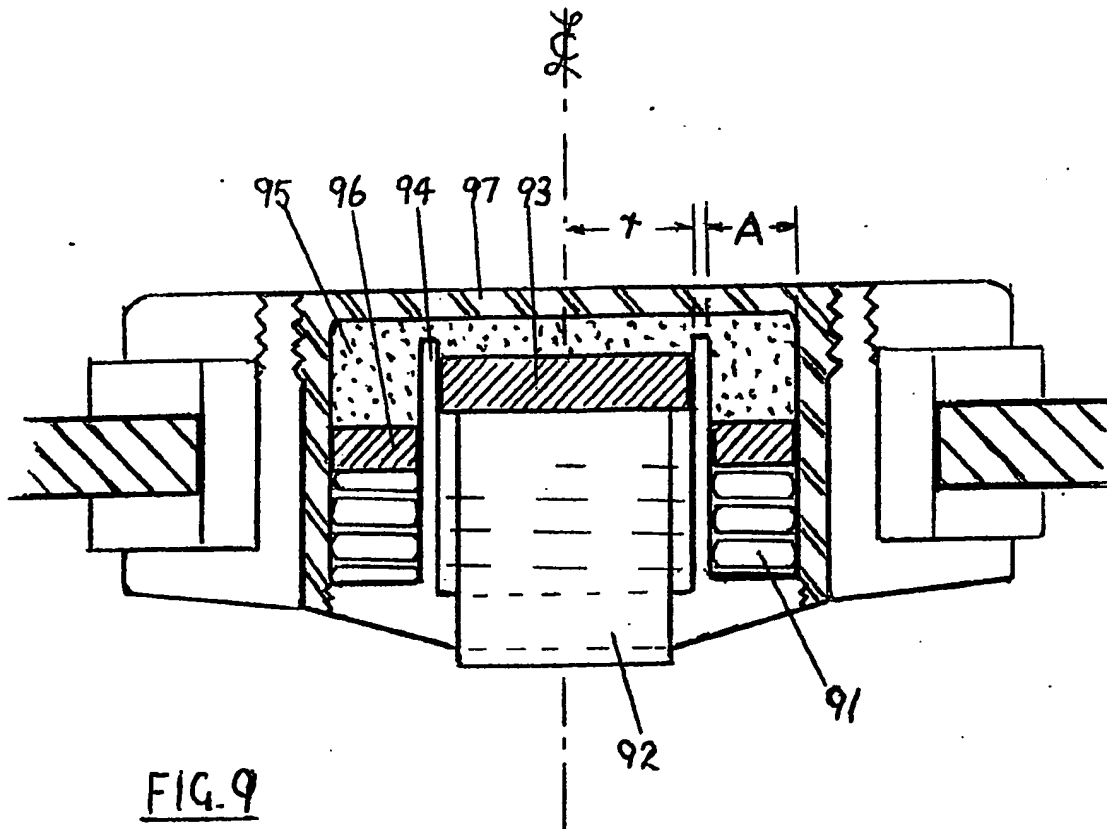
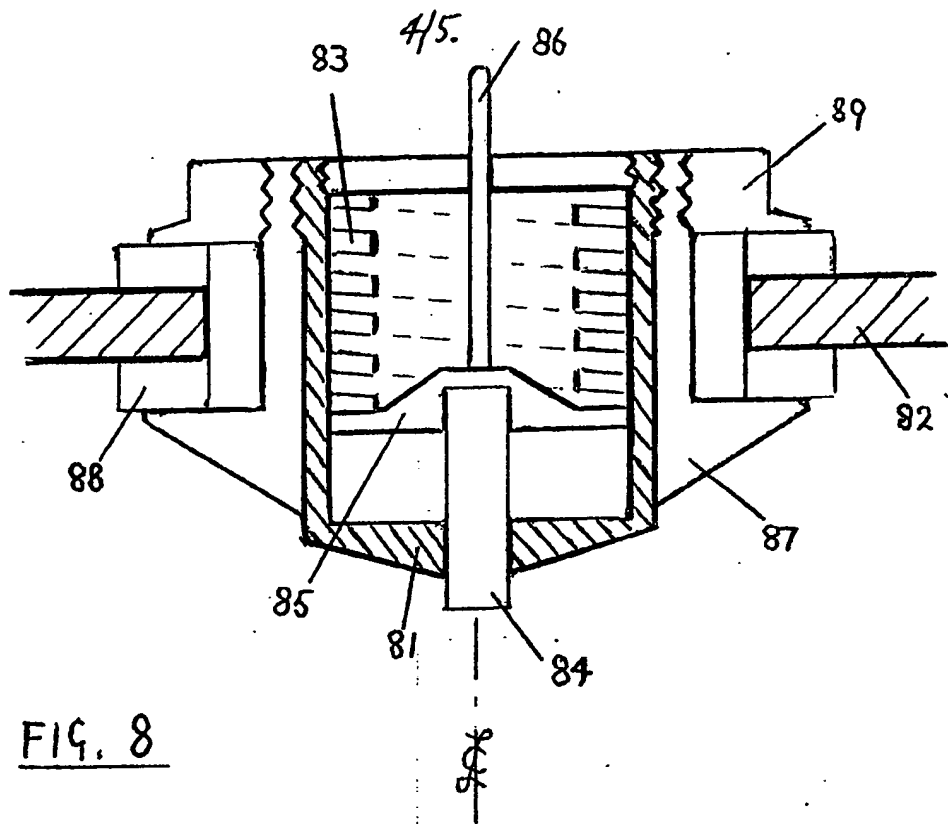


FIG. 7

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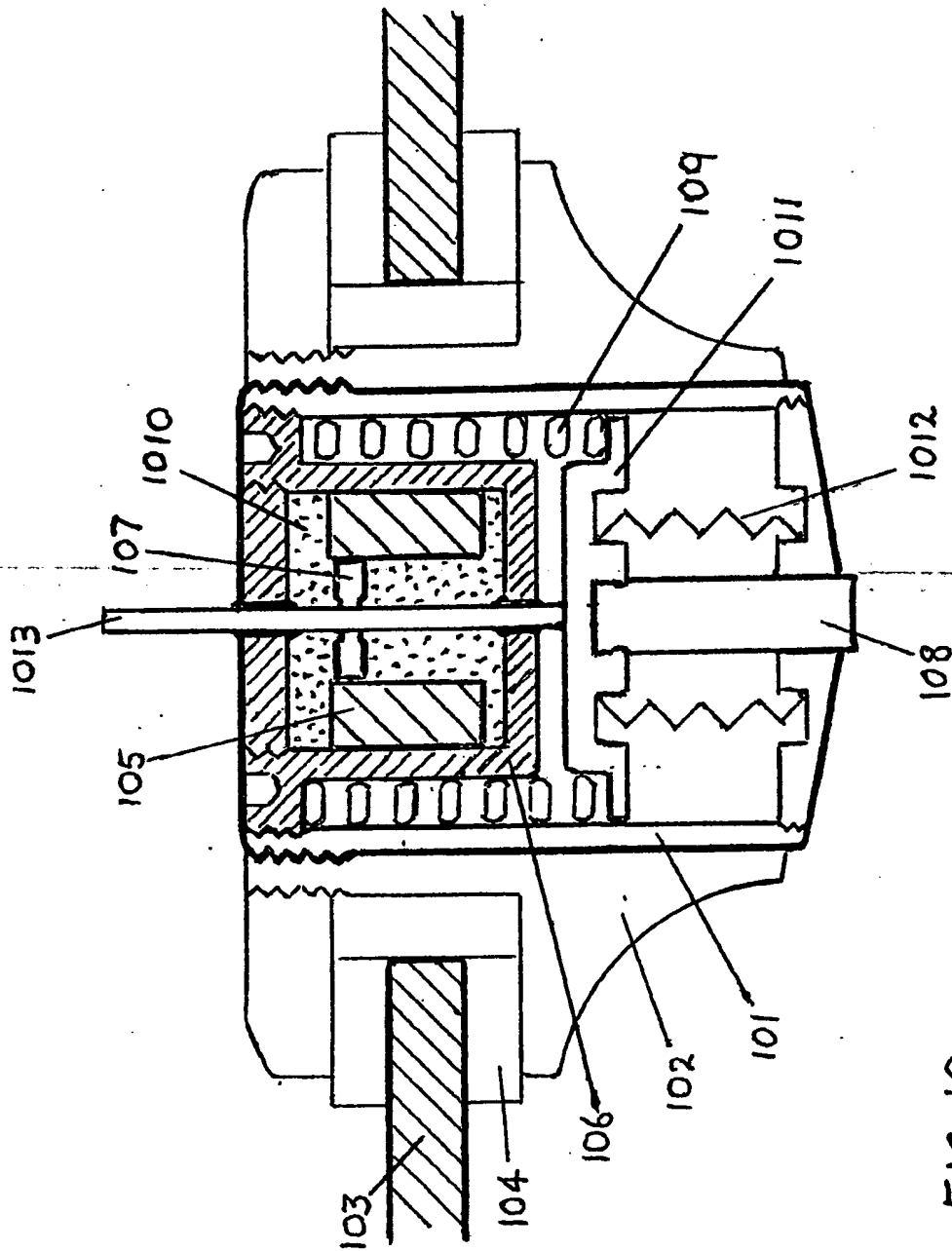


FIG. 10

## SPECIFICATION

### A compact electric motor

#### BACKGROUND ART

Brushholders for electric motors commonly allow the brush to slide in guide slots and press against the commutator under the force exerted by a spring. The slot allows the brush to slide towards the commutator as the brush wears due to abrasion and electrical effects with the revolving commutator.

A factor in brush motion is any slight unevenness, eccentricity, or any bearing slop of the commutator on its rotor shaft bearing. Yet another aspect of brush motion is that due to any vibration of the brushholder in a mode 'tangential' to the surface of the commutator as well as in the radial mode. Whilst the latter radial vibration of the brush-holder can be shown to not normally impart any significant pressures onto the brush, it would interfere with the working of the proposed inventions, which relate to brush/commutator vibrating pressures and uneven wear of the commutator. Accordingly two methods of reducing this interference are suggested, one of which is often used for other convenient purposes in small motors. This latter method is the use of radial type mounting as opposed to cantilever or torsional and other forms of support. In this case such radial mounting also lends itself to cartridge type replacement facility for the whole brush and brush-suspension system from outside the motor frame.

For where such radial mounting is not convenient, an alternative and novel anti-vibration device is described.

Radial mountings are sensibly rigid in the radial direction and easily made so in the tangential direction in order to obviate electrical commutation disturbances by tangential brush displacements.

But on rail and road traction motors there is also a large degree of vibration and shock accelerations of the whole motor due to rail, road, and undercarriage conditions. Such accelerations when in the line of direction of the brush slots, will mean that the motor frame and commutator moves whilst the radial inertia of the brushes can greatly affect the pressure between them and the commutator, and can even cause them to leave contact therewith. This varying pressure is the most likely cause of the costly uneven wear of the commutator.

A previous patent application entitled "Dynamic Brushholder for Electric Motors" describes a device to resist such vibratory pressures due to brush inertia, but the present invention describes a device to introduce an opposing vibration which can be arranged to largely cancel or even over-negate the unwanted vibratory pressures. This is done without affecting the brush freedom to adjust its position against the commutator as wear takes place. The new device, unlike the previous device, in that it is here inertia-controlled is likely to have smaller

problems of phase-change between the unwanted vibration effects and their correcting forces.

Again, a feature sometimes associated with smaller motors is that of a "radial commutator" rather than a cylindrical one. Fig. 1 shows these as 1 and 2 respectively. Fig 1 is a sectional representation of the commutator end of an electric motor, showing the arrangement of various features to be described. Otherwise 7 is the motor frame, 8 the rotor, 9 the field winding and 10 the rotor bearing. Brushholders are shown mounted at 11.

It seems first of all that the radial construction would have advantages for larger motors such as are used for traction purposes, and that these advantages might outweigh certain disadvantages, such as for instance the need for a wedge-shaped brush and slot configuration, which in the construction to be described will have minimal difficulty of production.

The advantages concerned with here, relate firstly to the likelihood of lower external impacts and accelerations in the axial mode 4 than in any radial mode 5, and thus correspondingly less effect of brush inertia with the brush pressing against the end face of the radial commutator than the periphery of the more commonly used cylindrical one. The axial mode disturbances are, on road and rail traction motors, likely to be in the nature of large displacements rather than large accelerations, due to the mechanics of road and rail 'holding', and the suspensions involved. Such construction has advantages for other brush suspensions than those of these inventions, but here in these inventions it also makes a possibly convenient alternative means of access, via the motor end plate.

This in turn leads to a further, most important advantage that can be gained by a combination of the above factors. That is, more winding space and power output could be obtained in the same motor space, particularly with the configuration of brushholder to be described, which could take up no greater thickness than is required for the rotor bearing of the motor.

Figure 1 which shows such a construction as will be made possible by these inventions, also shows the gain in winding space 6, and the short cartridge type brushholders 3 to be described.

#### AIMS AND SCOPE

This patent thus describes a brushholder device to counter uneven commutator wear, which for practical and essential installation and maintenance reasons involves the other devices described, that may have separate application and yet are also an essential part of the invention for many applications, and/or are also an integral extension of the patent to allow of greater power from the same, often limited, space available.

#### GENERAL DESCRIPTION

The general principle used to counter the brush-inertia pressure-variations is contained in the sectional schematic representation, Figure 2,

of a brushholder where a cylinder 21 attached via rigid insulation to the motor frame 22 contains a piston mass 23 which is free to slide in the cylinder. Another piston 24 is also free to slide and is connected to the brush 25. A fluid medium 26 causes the piston 24 to experience a force in one direction when the inertial forces of piston 23 and the brush are acting in the opposite direction. Thus the inertial forces on the brush being opposed by piston 23 enables more constant pressure between brush and commutator to be achieved. The pressure is supplied here by spring 27.

It will be seen that pistons 23 and 24 will make adjustments of their relative positions as brush wear takes place.

Before describing other aspects, the use of electrical analogues may clarify the difference in function between this part of the present invention, and the prior application entitled "Dynamic Brushholder for Electric Motors".

Accordingly, Fig. 3 is a much simplified electric circuit analogue of the basic vibratory function of a brushholder where, for reasons of easier visual interpretation of the diagram, the brush is considered to be free-floating and not restricted to contact with the commutator. Fig. 3 thus depicts motor mass 31, brushholder mass 32 and brush mass 33. The vibratory exciting force is 34, and the ensuing velocities imparted to the overall system are indicated by 35. The compliance of the pressure spring is 36, and 37 is that of the brushholder mounting in the motor. 38 would be the force normally exerted by the spring. The configuration thus shows relative motions 39 and 310 between commutator 312 and brush 33.

The above-mentioned prior application is clearly concerned with the insertion of a high resistance 313 in the path 39 of relative motion between brush and holder, and the elimination of compliance 37 so that the brush motion 311 would be the same as commutator motion 35.

The present invention uses another mass to "balance" the brush mass 33, and so we get the again simplified analogue of the present function, in Fig. 4.

Fig. 4 is an electrical analogue with some layout significance as well as its circuit significance. It depicts motor plus commutator mass 41, holder mass 42, and free-floating brush mass 43, and here the exciting forces are shown as an accelerative or gravitational field 44, which acts in the same instantaneous direction on 41, 42 and 43, to produce  $E_1$  and  $E_2$ . But pressure-spring 45 effectively by-passes  $E_1$  and 'short-circuits'  $E_2$ , as 'seen' by brush 43, so brush motion vectors  $i_1 + i_2$  approximately differs from that of the commutator by  $i_2$ . The correct insertion of mass 46 equal to mass 43 into the same excitation field 44 produces minus  $E_2$  and so eliminates  $i_2$ , and the brush then moves with the commutator at its velocity  $i_1$ .

Such analogues have limitations for logical reinterpretation. The function of connection 48 in relation to 47 is better demonstrated by Fig. 5.

Fig. 5 is a sectional representation of an anti-

vibration device that can readily be used with this type of construction in situations where direct 'radial' mounting may be impractical. The features of Fig 2 will be recognised in items 5 (1, 2, 3, 4, 5, 6, 7 and 8), but the main mounting is by insulator-cantilever 59. In order to reduce the probable vibration of this cantilever mounting without the need for heavy bracing, it may be possible to fix the lighter internal attachment 510 which only relates to vibration of the brush and pistons which are much lighter than the whole brushholder. A piston 511 in the fluid medium, holds the fluid to the motor-frame motion, and a fluid by-pass tube 512 allows an appropriate flow of the fluid to or from the rear of the piston in this case in order to accommodate the appropriate need at the other end of the main cylinder 51. Thus the fluid in the cylinder is "connected" to the motor frame and by-passes any relative brushholder vibration which would otherwise here cause brush pressure variations.

Where even this lighter radial fix is not possible, the device of Fig 6 might be appropriate, which has a cylinder and piston 13, that could be larger in order to regain the velocity ratio lost by its position along the cantilever mount. Alternatively the cylinder 613 could be separate, & just mounted on the holder, and connection 614 made by the well known metal hydraulic tubes.

Fig. 7 shows a brush "decoupling" device which may be needed to give a degree of freedom to the brush 75 for commutator eccentricities causing low velocity motion to the piston masses 73 & 74 as well as the brush. A piston 714 attached to the brush, reacts with the fluid medium in the small gap or orifice 715, to produce a resistive connection to the masses 73 & 74, and so reduce some of their inertial forces on the brush. Alternatively an elastic membrane may be used here or at 716.

## EMBODIMENTS

Fig. 8 is a sectional representation of a compact cartridge type holder 81, mounted in the motor frame 82. The shortness is achieved by using a short, large diameter spring 83. This presses on the brush 84 via the dry "piston" 85. 86 is an optional external brush-wear indicator. The cartridge assembly, or simply its brush and spring contents, is inserted via its mount 87 which is clamped onto its insulation 88 by nut 89. Means of location to the frame may be various and are not shown.

Fig. 9 is also a sectional representation and depicts an even shorter holder in a similar type of mount to that in Fig 8. Here the cartridge 97 contains an even larger dia. spring 91, which sits around the brush 92, which is attached to the piston 93 which has sealing rings and slides in the inner cylinder 94. The cavity 95 also contains a fluid medium which is pressed by the spring 91 via the annular piston 96 to put the required force onto piston 93 for the brush pressure. It will be

found that the wear take-up-length of spring travel can for instance be half that for the brush, if the width A is about 3/4ths of the radius r.

Instead of spring 91, brush pressure may be supplied by hydraulic tube from a separate cylinder mounted elsewhere & maybe feeding several holders. Piston 96 remains as inertial balancer, or cavity 95 could be eliminated.

Fig 10 is likewise a sectional representation of an embodiment, of the basic principle of inertial compensation, in a compact form that still retains a triple isolation of the brush from any hydraulic medium that may be used in the compensator. The cartridge body 101 fits into its mount 102 which is fixed to the motor frame 103 via insulation 104.

An annular piston 105 is free to slide in an inner cylinder 106 whilst a second piston 107 attached to the brush 108, slides within piston 105. The pistons are in a fluid medium 1010 in the cylinder 106. Spring 109 surrounding this cylinder, exerts the required pressure on the brush via the "dry" piston 1011 which also helps isolate the brush from cylinder fluid if such should get past the oil seals. Complete protection however could be by bellows 1012. If the brush-wear external indicator 1013 were omitted, or if the diameter of it were reduced above 107, then as brush wear proceeded, a tendency to decreasing pressure inside the inner cylinder would tend towards fluid retention.

The annular piston 105 needs little displacement to allow for normal total brush wear, if it has sufficient volumetric displacement relative to piston 107 and in fact a separate spring-centring of piston 105 might be preferable if piston leakage were made sufficient to accommodate brush wear. Such leakage would still allow a very-tight fluid connection between the pistons 105 and 107.

In all, a suitably short, safe, and stable holder could be made, to withstand adverse dynamic conditions, for the compact commutation system described.

New claims or amendments to claims filed on 3 Nov 1980. Superseded claims  
New or amended claims:—  
Claims 3, 4, 5 and 6 appended to claims 1 or 2.

## CLAIMS

1. A brushholder for an electric motor, having a mass which is free to slide in the same direction as that of the brush, and which mass would thus have inertial forces in the same direction as those of the brush, and which forces of the mass cause force to be exerted upon a fluid medium which in turn acts upon a piston attached to the brush, so as to oppose those inertial forces already acting upon that brush, which is otherwise free to slide for such purposes as wear, or low acceleration commutator deviations.

2. A brushholder as in claim 1, in which the brush has a measure of "decoupling" from its piston drive, by means of a compliant and/or resistive membrane, or through a second piston which is fluid resistance controlled in relation to the first.

3. A brushholder for an electric motor, with a hydraulic type piston device whereby a fluid or resistive medium is used to connect the holder or its internal brush suspension, to the motor, so that the holder or its brush suspension contents are less free to vibrate relative to the motor.

4. A brushholder for an electric motor, with a spiral compression or extension type brush-pressure spring which has equal or greater overall diameter than its average working length.

5. A brushholder for an electric motor where a piston attached to the brush is used to apply the brush pressure from hydraulic means, either from a piston in or on the holder, where the piston is pressured by a spring therein, or from an external pressure source connected by hydraulic means to the piston on the holder.

6. A brushholder for an electric motor with a hydraulic system to reduce the "travel" of the brush pressure-spring by means of the velocity ratio obtained between a large area "master" piston, and a smaller area "slave" piston.

7. A brushholder as in claim 1, where the piston & mass are mounted one within the other, either in mutual contact or separated by a wall or membrane.

8. An electric motor employing a combination of any one or more of the above claims 1, 2, 3, 4, 5, 6, 7 where commutation takes place via either the circumference of a cylindrical type commutator or the end face of a radial type, or a form intermediate between the two.